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의학석사 학위논문

Impact of a Hand Hygiene Campaign in a Tertiary Hospital in South Korea on the Rate of Hospital-Onset Methicillin-Resistant *Staphylococcus aureus* Bacteremia, and Economic Evaluation of the Campaign

국내 3 차병원에서 손위생 증진 캠페인이
메티실린 내성 황색포도알구균 균혈증 발생률에
미치는 영향 및 경제성 평가

2017 년 02 월

서울대학교 대학원

임상의과학과

전 준 영

A thesis of the Master's degree

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February 2017

Seoul National University

College of Medicine, Graduate School

Department of Clinical Medical Sciences

June Young Chun

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지도교수 오명돈

이 논문을 의학석사 학위논문으로 제출함

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전 준 영

전준영의 석사학위논문을 인준함

2017 년 01 월

위 원 장 _____ (인)

부위원장 _____ (인)

위 원 _____ (인)

Abstract

Impact of a Hand Hygiene Campaign in a Tertiary Hospital in South Korea on the Rate of Hospital-Onset Methicillin-Resistant *Staphylococcus aureus* Bacteremia, and Economic Evaluation of the Campaign

June Young Chun

Department of Clinical Medical Sciences

The Graduate School

Seoul National University

Introduction

Hand hygiene (HH) is the most important factor affecting health care-associated infections.

Methods

We introduced a World Health Organization HH campaign in Oct 2010. The monthly procurement of hand sanitizers per 1000 patient-days was calculated, and the monthly incidence of methicillin-resistant *Staphylococcus aureus* bacteremia (MRSAB), classified into community- and hospital-onset (HO), was measured from a microbiological laboratory database. Trends of MRSAB incidence were assessed using Bayesian structural time-series models. A cost-benefit analysis was also performed based on the economic burden of HO-MRSAB in Korea.

Results

Procurement of hand sanitizers increased 134% after the intervention [95% confidence interval (CI) 120% to 149%], compared to the pre-intervention period (Jan 2008-Sep 2010). In the same manner, HH compliance improved from 33.2% in Sep 2010 to 92.2% after the intervention. The incidence of HO-MRSAB per 100,000 patient-days decreased 33% (95% CI -57% to -7.8%) after the intervention. Since there was a calculated reduction of 65 HO-MRSAB cases during the intervention period, the benefit outweighed the cost (total benefit $851,565/total cost $167,495 = 5.08).

Conclusion

Implementation of an HH campaign leads to increased compliance. HO-MRSAB incidence was significantly reduced after the implementation. it is also cost-saving.

Keywords: Hand hygiene and MRSA bacteremia

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Contents

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Introduction

Healthcare-associated infections (HAIs) are a major concern in relation to patient safety and surveillance, and prevention is needed to control them. Among the interventions for infection control, hand hygiene is considered to be the main factor influencing the transmission of nosocomial pathogens (1, 2), and it could be cost-saving (3). There have been major campaigns to improve compliance with hand hygiene starting with the publication of the first national hand hygiene guidelines by the US Centers for Disease Control (CDC) in the 1980s (4). In 2005 the World Health Organization (WHO) launched *Clean Care is Safer Care*, which has been implemented worldwide.

HAIs are reported to account for 5-15% of hospitalized patients in developed countries and can involve 9-37% of those in intensive care units (ICUs) (5). Pittet et al. have reported their experience with the implementation of a multimodal hand hygiene campaign in Geneva University Hospital, which decreased overall nosocomial infections from 16.9% to 9.9% of patients (6). Strategies like this pioneer multimodal approach have proven to be effective in Australia (7), England (8) and the USA (9). In South Korea, however, there is little nationwide data (10) on the effects of hand hygiene campaigns (11).

Since *Staphylococcus aureus* is one of the most virulent and important pathogens, responsible for 10-20% of healthcare-associated bacteremia (12), *S.*

aureus bacteremia (SAB) has been used as a practical outcome measure for hand hygiene campaigns (7-9, 13). It has been estimated that the annual national incidence of hospital-onset SAB in Korea is 0.16/1,000 patient-days and its economic burden is $67.2 million (14). We aimed to assess the effect of a campaign to improve hand hygiene compliance on the incidence of hospital-onset methicillin-resistant *S. aureus* bacteremia (MRSAB) and to analyze its economic benefit (14).

Methods

Hand hygiene promotion program

Since October 2010, a hand hygiene campaign consistent with the WHO multimodal hand hygiene improvement strategy has been implemented in Seoul National University Bundang Hospital (SNUBH) (5).

System change is considered a very important component of the WHO strategy. Therefore, as a first step, disposable alcohol-based hand rub sanitizers were placed by every bed, and were wall-mounted in front of each room in every ward. Second, training and education were emphasized. Annually, all HCWs including doctors, nurses and other healthcare workers completed an obligatory web-based learning program on hand hygiene. Based on annual data obtained by monitoring hand hygiene, target groups whose compliance rates were low were obliged to receive additional intensive education. Also, at the beginning of every month, new hospital employees were taught about infection control and hand hygiene procedures.

The third strategy consisted of evaluation and feedback. The hand hygiene performance of doctors, nurses, and other healthcare workers was monitored monthly by 4 trained observers using predetermined criteria for quantitative evaluation. Consistency among observers was validated by ensuring at least 90% agreement for simulations. Feedback about hand hygiene performance was given to the health care workers immediately after observations, and to each department at the end of the month. Health care workers were strongly

encouraged to adhere to hand hygiene procedures by rewarding compliers with both incentives and certificates quarterly.

Fourth, as reminders to the workforce, several campaigns were conducted to publicize the hand hygiene strategy through posters, flags and screen savers. Lastly to promote an institutional safety climate, patients were educated via a standardized, educational video on hand hygiene when they were first admitted. Moreover they were encouraged to evaluate the hand hygiene performance of HCWs using feedback compliment cards.

Study population and data collection

SNUBH is a 1241-bed, tertiary care, university-affiliated teaching hospital in South Korea. It has 28 general wards, 7 intensive care units (ICUs) with 107 beds (16 medical ICU, 9 cardiovascular ICU, 12 oncology ICU, 16 surgical ICU, 4 emergency ICU, 15 neuro ICU and 35 neonatal ICU), and an emergency department. Almost 80% of the bedrooms on the general wards have 4-5 beds.

From January 2008 through December 2014, we collected retrospective data from the microbiological laboratory database on patients who had SAB. SAB was defined as at least 1 positive culture out of 2 pairs of blood cultures. SAB was classified as methicillin-susceptible *S. aureus* bacteremia (MSSAB) or MRSAB, and MRSAB was classified as community-onset (CO) or hospital-

onset (HO). HO-MRSAB was defined by a positive blood culture more than 3 days after admission, and the others as CO-MRSAB.

The monthly procurement (volume, mL) and cost (USD) of waterless hand rubs (e.g. alcohol-based hand rubs, chlorhexidine and quaternary ammonium compounds) were also measured during the study period. All this information was retrieved from the central store of the hospital, and was assessed in the same way throughout the study period.

Statistical analysis

The monthly procurement of hand sanitizers (mL) and their monthly cost (USD) were expressed per 1,000 patient-days, and monthly incidence rates of MRSAB were expressed per 100,000 patient-days. We assessed temporal trends in the above data, and the effect of the hand hygiene campaign on both procurement of hand sanitizers and rates of MRSAB.

The intervention was started in October 2010, and the study period was divided into pre-intervention (January 2008 to September 2010) and intervention periods (October 2010 to December 2014).

To investigate the causal impact of the intervention on trends of MRSAB incidence, we applied Bayesian structural time-series models using R-package (http://google.github.io/CausalImpact/) (15). Using the value of the pre-

intervention period as a potential control, a counterfactual prediction for the intervention period was inferred. Subtracting the predicted from the observed value during the intervention period gave the Bayesian pointwise causal effect.

Economic evaluation

The cost-benefit analysis of the campaign was carried out by calculating the maintenance costs, and the benefit from the reduction of HO-MRSAB. The maintenance costs consisted of the increased hand sanitizer consumption, the cost of the hand hygiene campaign and the salary of 1 employee added to the infection control office for the campaign. The number of expected episodes of HO-MRSAB averted by the campaign was analyzed using Bayesian models. The economic burden including the additional medical costs of HO-MRSAB and the costs of caregiving were taken from our previous study (14) and used to infer the benefit provided by the hand hygiene campaign. Briefly, the additional medical costs of HO-MRSAB were calculated by subtracting the median hospital costs of control patients who were free of any nosocomial infections during hospitalization from those of HO-MRSAB patients. Hospital costs were derived from the National Health Insurance Service of South Korea. The cost of caregiving was calculated as the product of the daily cost of a hired caregiver and the excess length of stay.

Ethics statement

This study was approved by the Institutional Ethics Review Board of SNUBH (No. B-1601-330-106).

Results

Hand hygiene compliance and trends in hand sanitizer procurement

The baseline hand hygiene compliance rate was 33.2% in September 2010 (pre-intervention period). Following the start of the hand hygiene campaign in October 2010, compliance increased to 92.2% by November 2014 (Figure 1). During the pre-intervention period, monthly performance rates varied substantially but reached a plateau of 90% by 2013. On average, 1,000 events were monitored monthly.

After the start of the hand hygiene campaign, the procurement of hand sanitizers increased from 8.55 (January 2008) and reached a maximum of 25.82 L (March 2013) per 1,000 patient-days. During the intervention period, it averaged 15. In the absence of an intervention, we would have expected an average value of 6. The Bayesian model showed that the procurement of hand sanitizers increased 134% after the start of the intervention [95% confidence interval (CI) 120% to 149%] (Figure 2A). The median value of hand sanitizer procurement was 5.56 [Interquartile range (IQR) 3.03] during the pre-intervention period, and 14.50 (IQR 4.44) during the intervention period.

Trends in SAB rates

From January 2008 to December 2014, 372 episodes of MSSAB and 470 of

MRSAB were detected. MRSAB was classified into CO-MRSAB (n=225) or HO-MRSAB (n=245). The incidence of HO-MRSAB declined from a peak of 31.92 cases per 100,000 patient-days in August 2008 and an average of 14 during the pre-intervention period to an average of 9 during the intervention period. In the absence of the intervention we would have expected an average of 14. According to the Bayesian model, the incidence of HO-MRSAB decreased by 33% compared to the pre-intervention period (95% CI -57% to -7.8%) (Figure 2B). This corresponds to a reduction of 65 episodes in absolute terms during the intervention period. The median value of the HO-MRSAB incidence rate during the pre-intervention period was 12.11 (IQR 11.79), and during the intervention period it was 8.03 (IQR 8.77). However the incidence rates of MSSAB and CO-MRSA increased by 60% (95% CI 33% to 88%) and 63% (95% CI 18% to 106%), respectively, during the intervention. The median value of the MSSAB incidence rate during the pre-intervention period was 11.59 (IQR 8.70), and during the intervention period it was 18.64 (IQR 12.21). Likewise, the median value of the CO-MRSAB incidence rate during the pre-intervention period was 7.68 (IQR 11.60), and during the intervention period 9.75 (IQR 14.30).

Economic evaluation

The hand hygiene campaign led to an estimated reduction of 65 (95% CI 12 to 112) cases of HO-MRSAB during the intervention period. Based on our previous data (14) giving the economic burden of 1 case of HO-MRSAB as

$13,101, the cost offsets of the hand hygiene campaign was $851,565. The costs of hand sanitizer consumption, the hand hygiene promotion campaign and the increased personnel totaled $167,495.

Thus the savings in terms of averted HO-MRSAB outweighed the costs of the campaign (Table 1), and the benefit-cost ratio was 5.08 (95% CI 0.94 to 8.76).

Figure 1A.

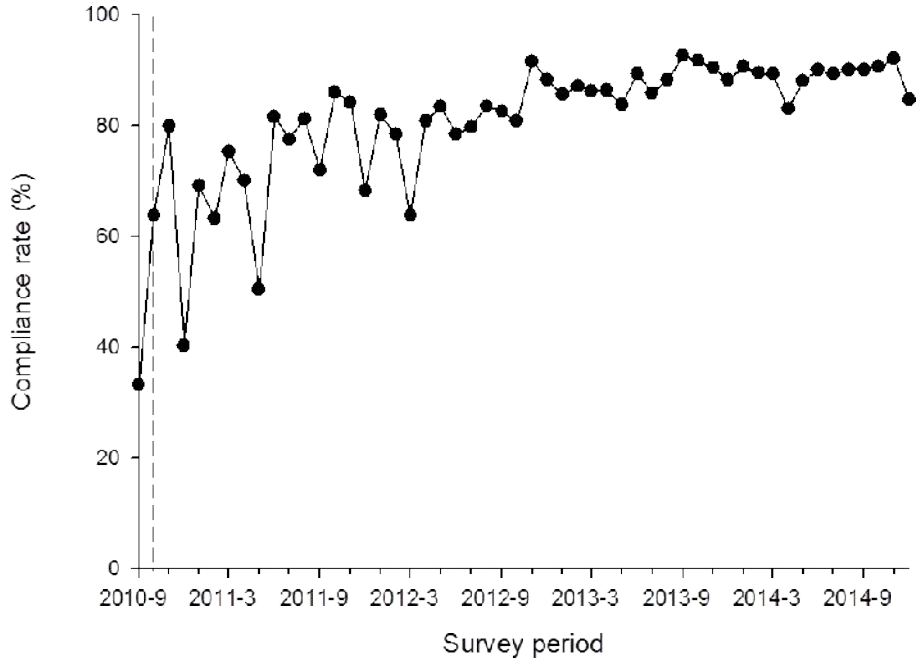


Figure 1B.

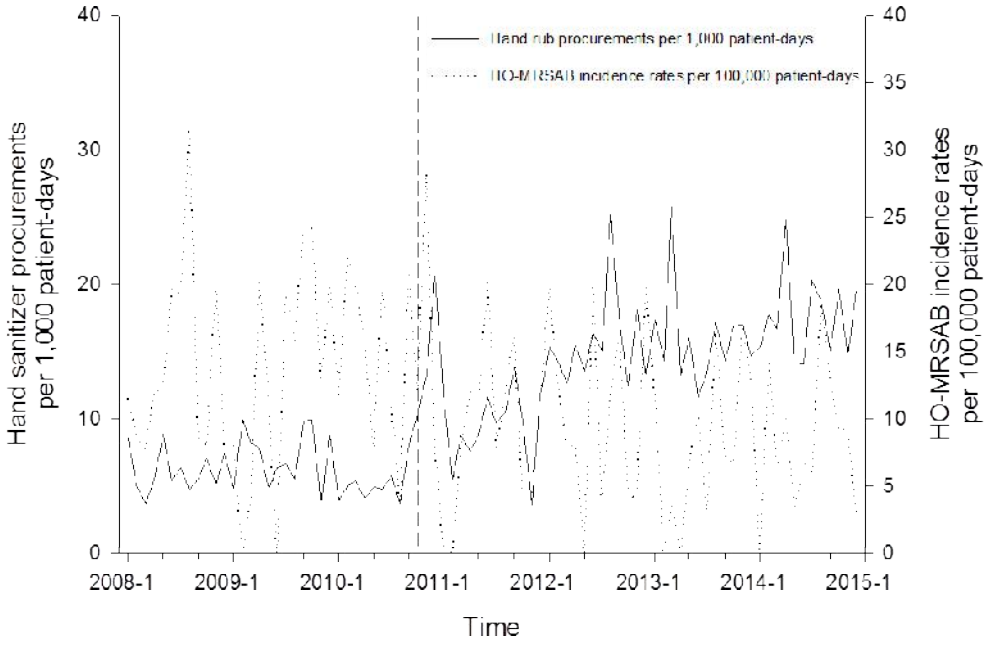
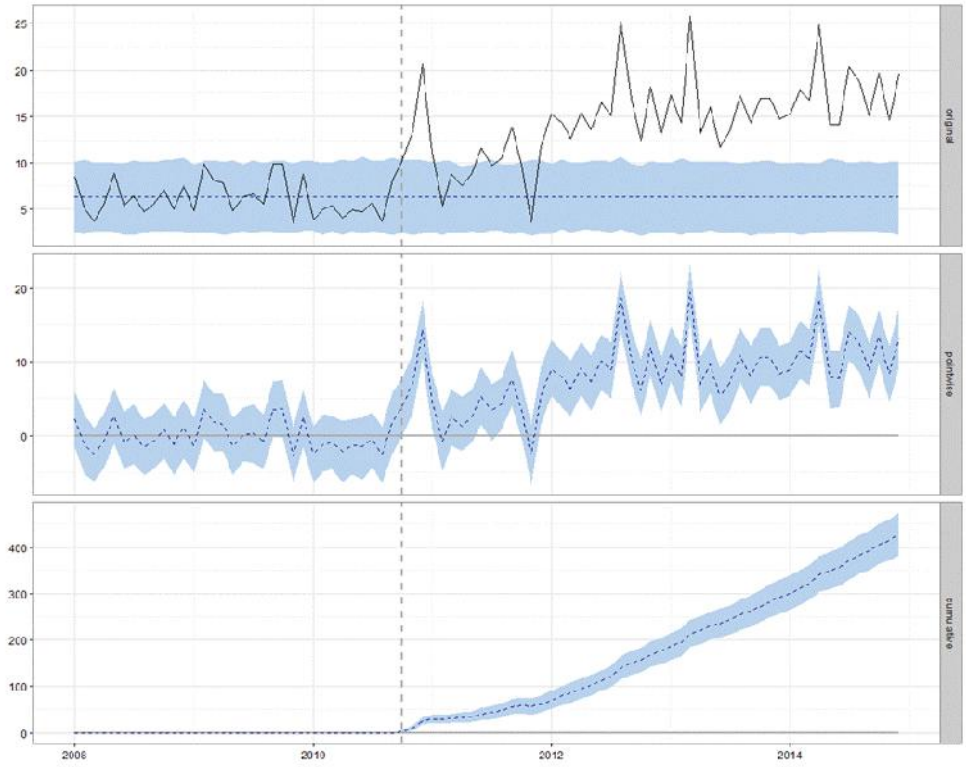


Figure 1. Trends in hand hygiene compliance, hand sanitizer procurements, and hospital-onset methicillin-resistant *Staphylococcus aureus* bacteremia incidence rates from January 2008 to December 2014. (A) Hand hygiene compliance, filled circles (●) (B) hand sanitizer procurements, solid line (—); HO-MRSAB incidence rates, dotted line (···). The vertical dashed line (---) separates the pre-intervention and intervention periods.

Figure 2A.


original
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25
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Figure 2B.

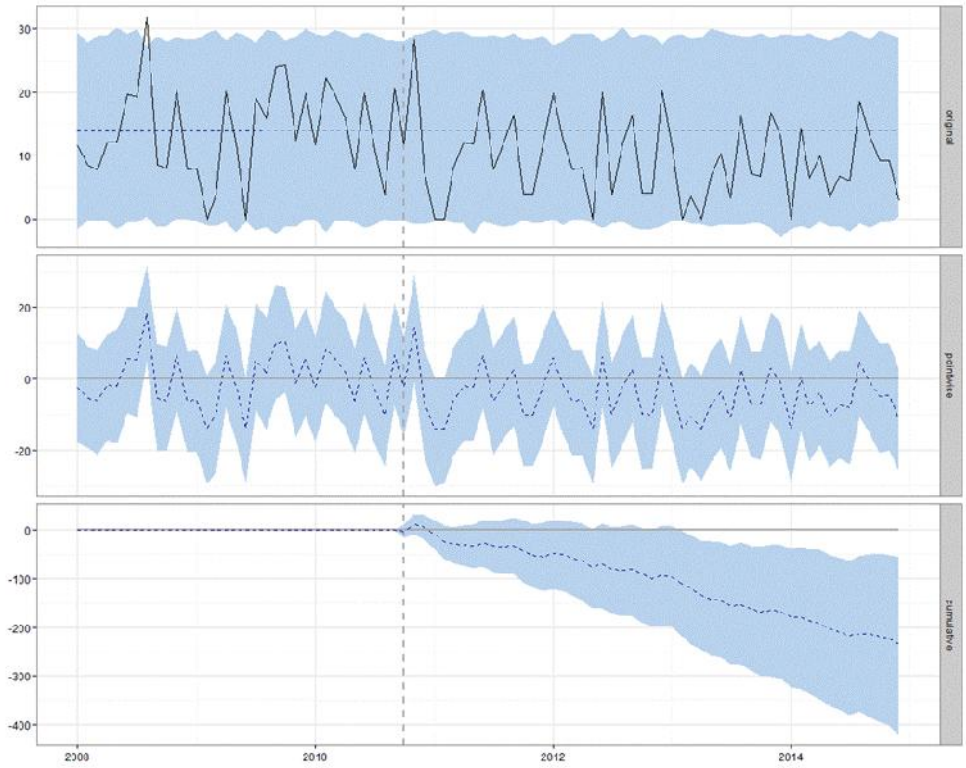
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Figure 2. Impact of the hand hygiene campaign (October 2010, vertical dashed line) on (A) hand sanitizer procurement and (B) hospital-onset methicillin-resistant *Staphylococcus aureus* bacteremia incidence rates.

In the 1st column, the solid line shows the original data and the shadowed area shows the counterfactual prediction for the intervention period, based on the trend of the pre-intervention period, if the intervention had not taken place. The 2nd column shows the difference between the original data and the counterfactual prediction, which is called the pointwise causal effect. The 3rd column is the cumulative pointwise contribution.

Table I. Cost-benefit Analysis of the Hand Hygiene Campaign.

Parameter	Value [95% CI]
Episodes of HO-MRSAB	
Observed	130
Predicted	195 [145 to 242]
Total reduction (%)	65 (33%) [12 to 112]
Savings due to HO-MRSAB prevention	$ 851,565[a]
Maintenance costs of the hand hygiene campaign	
Total hand sanitizer costs	$ 21,294
Campaign costs	$ 8,182
Personnel costs	$ 138,019
Total costs	$ 167,495
Benefit-cost ratio[b]	5.08 [0.94 to 8.76]

[a]All monetary values are expressed in US dollars. The average exchange rate in 2015: 1 US dollar=1,100 KRW.

[b]Benefit cost ratio=benefit/cost

Discussion

There is a clear association between hand hygiene and HAIs, especially in the case of MRSA (6-9, 16). In this paper, we assessed whether a WHO *Clean Care is Safer Care* campaign was effective in reducing HAIs in South Korea and whether it was also cost-saving.

Excellent hand hygiene compliance was achieved by the hospital-wide hand hygiene campaign, and it was maintained for 2 years throughout the campaign. Because of the situation in Korea in which most common types of hospital room contain multiple beds, infection control by reducing contact could be expected to be more challenging. Despite this limitation, we believe that placing hand sanitizers by every bed led to a dramatic improvement in hand hygiene compliance. Although there may have been a Hawthorne effect on hand hygiene compliance from the direct observation method, we see the increasing trend in hand sanitizer procurements as indirect confirmation of the observed hand hygiene compliance. This campaign resulted in a measurable reduction of HO-MRSAB incidence rates, which was confirmed by a Bayesian structural time-series analysis. The costs of the campaign were low in comparison with the savings from the reduction in nosocomial bacteremia.

This study had a few limitations. First, the data were obtained from a single center, rather than being obtained nationwide, and this highlights the need for a nationwide study in Korea. The first cost-benefit analysis of a national hand hygiene campaign (NHHC), in Australia, was published recently and it proved

to be cost effective (17). A pilot NHHC has been initiated in 35 Korean hospitals, but it is too early for it to achieve outstanding results (18). We anticipate a similar outcome for that study, and our study may help lay the groundwork for it. Second, there was lack of hand hygiene compliance data before the roll out of the campaign. Since there is only one time point before the beginning of the intervention regarding hand hygiene compliance, it has limitation to show direct relationship between the campaign and hand hygiene compliance. In a systematic review (19) by Erasmus et al., the overall hand hygiene compliance rate was 40%, which was similar to our figure during the pre-intervention period. In addition, the fact that hand hygiene compliance rates rose steeply after the start of the hand hygiene campaign might probably indicate the association between the two factors. Third, other infection control measures were in force in SNUBH, and these could be confounding factors for the reduction in MRSAB rates. However these other measures such as contact precautions, antibiotic stewardship, and environmental cleaning, underwent no major changes during the study period except for central line-associated bloodstream infection (CLABSI) intervention. This CLABSI prevention approach, which followed the Institute for Healthcare Improvement (IHI) guidelines, was implemented in 2012. Its 5 core components were hand hygiene, maximal barrier precautions, chlorhexidine skin antisepsis, optimal site selection and daily review of line necessity. According to the surveillance data from our infection control office (data not shown), there was no significant change in the prevalence of nosocomial infections after the introduction of the CLABSI. It can therefore be inferred

that the hand hygiene campaign itself might be responsible for the decreased HO-MRSAB incidence. Fourth, we did not carry out hospital-wide surveillance of nosocomial infections other than SAB, only targeted surveillance of bloodstream infections, pneumonia, and urinary tract infections in ICUs. Hence, the impact of the hand hygiene campaign on other nosocomial infections caused by vancomycin-resistant enterococci and carbapenem-resistant *Enterobacteriaceae* could not be evaluated. Lastly, this hand hygiene campaign focused mainly on doctors, nurses and other healthcare workers. Patients' caregivers and family members may also play an important role in transmission of nosocomial pathogens.

The incidence rates of MSSAB and CO-MRSAB have tended to increase throughout the study; only HO-MRSAB decreased after the hand hygiene campaign started. This is in accordance with Korean national surveillance data reporting an increase in CO-MRSA (20, 21). It suggests that hand hygiene is more effective at interrupting exogenous transmission, the likely route for HO-MRSA in hospital settings, than at interrupting endogenous transmission, the likely route for MSSA and CO-MRSA. Similar results have been reported in England and elsewhere (8, 22).

According to a systematic economic evaluation of interventions for preventing HAIs (23), such interventions were beneficial in many cases. Most of the studies were performed in North America or Europe and on average the savings were 11 times the costs. Most of the intervention aimed to reduce person-to-person transmission by hand decontamination. The cost-benefit

analysis in this study gave a similar result (a benefit-cost ratio of 5). Moreover, this study conducted in South Korea adds one more meaningful outcome to the few Asian studies carried out so far.

In conclusion, this single center study in Korea demonstrates that a hand hygiene campaign improves hand hygiene compliance and could reduce HO-MRSAB. The current pilot national hand hygiene campaign should be expanded as soon as possible in order to increase the benefits of the limited national health budget as well as to obtain a reliable cost-benefit analysis from a multi-center study.

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초 록

배경:

의료관련감염의 관리에 손위생은 가장 실천하기 쉽고도 중요한 역할을 한다고 알려져 있다. 그 중요성에도 불구하고 아직 국내에서 손위생이 의료관련감염에 어떠한 영향을 미치는지에 대한 연구가 부족한 실정이다.

방법:

국내 3차병원에서 2010년 10월 세계보건기구(World Health Organization)의 손위생 증진 캠페인을 도입하였다. 1000 재원일수당 월별 손소독제 사용량과 메티실린 내성 황색포도알균 균혈증의 발생률을 지역사회발병(community-onset)과 병원발병(hospital-onset)으로 구분하여 조사하였다. 메티실린 내성 황색포도알균 균혈증의 발생률 변화 양상을 베이지안 시계열 모형(Bayesian time-series analysis)으로 분석하였다. 또한 기존에 알려진 메티실린 내성 황색포도알균 균혈증의 경제적 손실비용을 이용하여 손위생 증진 캠페인의 비용-효과 분석을 시행하였다.

결과:

손소독제 사용량은 캠페인 도입 전(2008년 1월 ~ 2010년 9월)에 비하여 캠페인 이후 134% (95% 신뢰구간 120% ~ 149%) 증가하였다. 손위생 수행률은 캠페인 직전인 2010년 9월 33.2% 였으나 캠페인 이후 최대 92.2%까지 상승하였다. 캠페인 이후 병원발병 메티실린 내성 황색포도알균 균혈증의 100,000 재원일수 당 발생률은 33% (95% 신뢰구간 -57% ~ -7.8%) 감소하였다. 베이지안 시계열 모형으로 예측한 병원발병 메티실린 내성 황색포도알균 균혈증의 실제 감소치는 65명으로 알려진 경제적 손실비용을 이용하여 계산하였을 때 효과가 캠페인에 든 비용을 상회함을 알 수 있었다 (총 이익 $851,565/총 비용 $167,495 = 5.08).

결론:

손위생 증진 캠페인 도입 후 손위생 수행률이 향상되었고 병원발병 메티실린 내성 황색포도알균 균혈증의 발생률이 감소하였다. 손위생 증진 캠페인은 비용 효과적이었다.

주요어: 손위생, 메티실린 내성 황색포도알균 균혈증
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